

1 417 696

- (21) Application No. 60004/71 (22) Filed 23 Dec. 1971
 (23) Complete Specification filed 22 Dec. 1972
 (44) Complete Specification published 17 Dec. 1975
 (51) INT. CL.² D04H 1/42 1/48 1/58
 (52) Index at acceptance

DIR 3A2G1 3A2G2 3A2M2 3A2M3 3A2MX 3A2MY
 3A2Q1 3A2Q2 3A2Q3 3A2QY 3B4 3C1B 3C1C
 3C1X 3C1Y 3C2B 3C2X 3C2Y 3D1A2A1 3D1A2B
 3D1A3A 3D1AY 3D1C2 3D1D 3D2A 3D2B 3D3B
 3D3C 3D3E 3D3F 3D3H 4

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(54) NON-WOVEN FILTER MEDIUM

- (71) We, LANTOR LIMITED, a British Company, of Rumworth Mill, St. Helens Road, Bolton BL3 3PR, Lancashire, and AUTOMOTIVE PRODUCTS LIMITED, A British Company, of Tachbrook Road, Leamington Spa, Warwickshire, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

The present invention concerns a non-woven filter medium.

- Filter media for filtering organic solvents such as for example kerosene and gas turbine fuels have up to now been made from materials such as metallic mesh structures or papers or textile fabrics impregnated with phenolic resin.

- There is a limit on the temperature at which these phenolic papers and fabrics can be used, however, because at temperatures above 200°C. they start to decompose. With the advent of high performance gas turbine engines for supersonic aircraft and modern fuel technology where the use of very high temperature fuels is envisaged, a filter medium stable at temperatures in excess of 200°C. has become necessary for certain designs of fuel filter.

- A very fine pore size could be obtained with a woven mesh and high temperatures could be used with, for example, a woven stainless steel gauze but the weight factor combined with the relatively short time before such material is blocked by the contaminants, makes such a filter structure undesirable.

- A non woven fibrous structure is an efficient filter medium in that it offers an open, low density structure having, weight for weight, a greater dirt holding capacity than woven or knitted structures. The pore size of such a non-woven filter can be va-

ried by varying the fibre denier, the fibre to resin ratio and by consolidating the fabric to calculated densities or by a combination of these variables.

According to the present invention a filter medium is provided comprising a non-woven web of fibres of a condensation product of *m*-phenylene diamine and isophthalic acid which are stable to temperatures in excess of 200°C., preliminarily bonded by chemical and/or physical means and then further bonded with an organic thermosetting resin which is a condensation product of an aralkyl ether and phenol that is heat resistant to temperatures in excess of 200°C.

A suitable high temperature resistant fibre for the web is a poly-(*m*-phenyleneisophthalamide fibre sold under the Du Pont registered Trade Mark 'NOMEX'.

A suitable thermosetting resin is that sold as XYLOK 210 ('XYLOK' is a registered Trade Mark).

With a non-woven structure a binder is necessary to hold the fibres firmly in the matrix and this is provided by the organic resin. In providing structural strength the resin prevents the fibres from compacting under flow and pressure and also may improve the chemical resistance of the medium.

The web may be made, for example, by carding, garnetting or air deposition of the fibres and formed in a cross-laid, randomly laid or parallel laid manner. The web may consist of fibres of one denier only, or alternatively it may consist of a blend of coarse and fine deniers. Multiple layers of fibres of differing deniers may also be used.

In between the web forming stage and the further bonding with the high temperature resistant resin, a preliminary bonding takes place to produce a more dimensionally stable web having greater de-

lamination strength. This may be either by means of mechanical bonding such as for example needlepunching or stitch bonding with or without a yarn e.g. with an Arachne or Arabeva type machine or by chemical bonding using, for example, a natural or synthetic latex, such as a styrene-butadiene copolymer, or a vinyl acetate-vinyl acrylate copolymer or by a combination of both mechanical and chemical bonding. The choice of the nature of this preliminary bonding is governed by several factors, such as resin/fibre compatibility and filtration properties required of the final filter structure, as explained below.

If chemical bonding is employed, after impregnation the excess binder may be removed by squeezing rollers or by suction and the web can then be dried. During the drying process, the binder can be made to migrate to the surface from which drying takes place so that the fabric at this stage may have a binder-rich face and a binder-deficient face. This non-uniform distribution of binder at this stage contributes to the final filtration properties of the filter structure and the extent to which migration of the binder is allowed to take place is governed by the required properties of the filter. After drying, the fabric may, if required, be consolidated by pressing.

The fabric is then passed through a bath of the high temperature resistant solvent based resin, through nip rollers and along a drying lattice or is passed through a bath of the resin in solution and up a drying tower. If the fabric is dried on a vertical drying tower heated on both faces, then the resin tends to migrate to each surface and the distribution of the resin throughout the fabric is more uniform than if the fabric is dried on a horizontal lattice. In the case where a horizontal lattice is used and the hot air is directed onto the top surface of the fabric, the migration of the resin is towards the top drying surface and so the resin can be made to migrate towards or away from the original preliminary binder rich face depending upon whether the fabric is passed along the drying lattice with the binder-rich face or binder-deficient face downwards. An alternative method of coating one surface to the fabric is by back filling or coating from the underside followed by drying.

After removing the solvent, the fabric may be pressed at a suitably high temperature to compress the fabric to a desired density and partially to cure the resin to obtain strength and stability. In this form the fabric may be pleated and formed to produce a filter structure and finally the fabric is heated at an elevated temperature to cure the resin fully and set the fabric in

the pleated form. After removal of solvent the fabric if desired may be pleated and formed to produce a filter structure and then heated to cure the resin in one step.

The choice of the high temperature resistant resin and fibre has to be made carefully. The resin and fibre need to be compatible, i.e. the high temperature resin solution should wet out the fibre and form a skin around the fibre. If the fibres and the resin do not have good compatibility, then the compatibility may in some cases be improved by the application of the preliminary bonding agent. For example, it has been found that NOMEX (Du Pont) and XYLOK 210 (Midland Silicones) do not have good compatibility, and the fibres do not easily become impregnated with the resin during the further bonding stages; excessive migration during drying is liable to occur resulting in the fabric having only low delamination strength. If, however, a polyvinyl acrylate — polyvinyl acetate latex is used as a pre-bonding agent, then the compatibility of the resin and the fibre is improved and the resin wets the fibre out more easily. This may be due to the fact that the methyl ethyl ketone which is present as a solvent for the resin is also a solvent for the polyvinyl acrylate-polyvinyl acetate binder and so the binder absorbs a relatively large quantity of methyl ethyl ketone and also swells a considerable amount, so enabling the resin solution to come into close contact with the fibre. If there is a non-uniform distribution of binder from one face to the other, then the resin solution will, initially, be preferentially held in the binder-rich face. If this binder-rich face is downwards on a horizontal drying lattice and the hot air drying system is directed towards the top surface of the fabric so that evaporation takes place from this side then migration of the resin is towards the top surface and takes place as the solvent evaporates. The final resin distribution therefore depends on the resin concentration in the solution, the expression of the squeezing rollers or suction box, and the distribution of the preliminary binder.

After the fabric has been pressed to the required density or gauge and the filter structure formed, the final stage of curing the resin takes place. This is preferably carried out at high temperature according to the resin manufacturer's instructions, so that during this curing at high temperatures any preliminary binder present decomposes and considerable weight loss in the fabric is experienced. This decomposition and removal of the preliminary binder produces voids in the fabric and so the nett result is the production of a gradation in the density of the filter

which ensures a more efficient filter with better dirt holding capacity than if a uniformly dense fabric of fine pore size were used.

- 5 It is possible that with certain fibres and resins the compatibility is sufficient for good wetting out of the fibre without the use of a chemical preliminary bonding agent. In such a case a mechanical bonding could be employed such as needle-
- 10 punching and the web impregnated with the resin without further processing.

The invention is illustrated by the following Example.

15 *Example*

A randomly laid web of 2 denier 2" staple NOMEX was produced at 2.75 oz/sq. yard to 3.25 oz/sq. yd. and passed through a saturating bath of a polyvinyl acrylate — polycinyl acetate latex — National 125-2820 at 7% solids in water. The excess latex was vacuum extracted and the web was dried at 120°C. to 135°C. The fabric now contains approximately 12-20% of the binder by weight. During this bonding process, the binder is liable to migrate towards the surface from which the drying takes place

20 producing a binder-rich and a binder-deficient side.

This prebonded fabric was then further bonded with XYLOK 210. The fabric was passed into a bath of XYLOK 210 in solution, in methyl ethyl ketone at a solids content of 5%, passing under a guide roller and then through two nip rollers to remove excess resin solution. The total dwell time of the fabric in the resin solution was about 3-5 seconds to allow the fabric to wet out thoroughly in the resin solution. The pressure of the nip rollers on the fabric governs the resin content of the fabric after drying. The fabric was then passed

25 along a drying lattice at a temperature of 120°C. to 135°C. with the original prebond binder-rich face downwards on the lattice so that the resin migration during drying was towards the binder-deficient side. At this stage the fabric contained approximately 20% of resin calculated on the weight of the fibre.

The fabric was then pressed at a temperature of 140°C.—150°C. for 10—15 minutes to a thickness of 12 thou. This gauge had previously been calculated to give the required density for optimum filtration properties. The resin at this stage is in a partially cured state and the fabric although dimensionally stable is capable of being pleated and formed into the desired filter shape. After the filter structure has been formed to cartridge is heated at high temperature to cure the resin fully and to

30 degrade and remove the prebond binder

and thus obtain optimum filtration properties.

WHAT WE CLAIM IS:—

1. A filter medium comprising a non-woven web of fibres of a condensation product of *m*-phenylene diamine and isophthalic acid which are stable to temperatures in excess of 200°C., preliminarily bonded by chemical and/or physical means and then further bonded with an organic thermosetting resin which is a condensation product of an arakyl ether and phenol that is heat resistant to temperatures in excess of 200°C.
2. A filter medium as claimed in claim 1 in which the fibres are poly-(*m*-phenyleneisophthalamide) fibres.
3. A filter medium as claimed in claim 1 or 2 in which the preliminary bonding is chemical bonding by a natural or synthetic latex.
4. A filter medium as claimed in claim 1 or 2 in which the preliminary bonding is mechanical bonding by needlepunching or stitch-bonding with or without a yarn.
5. A method for the preparation of a filter medium which comprises treating a non-woven web of fibres of a condensation product of *m*-phenylene diamine and isophthalic acid which are stable to temperatures in excess of 200°C., preliminarily bonded by chemical and/or physical means, with an organic thermosetting resin which is a condensation product of an arakyl ether and phenol that is heat resistant to temperatures in excess of 200°C.
6. A method as claimed in claim 5 in which the fibres are poly-(*m*-phenyleneisophthalamide) fibres.
7. A method is claimed in claim 6 in which the preliminary bonding is by impregnation with a chemical binder, any excess binder being removed by squeezing rollers or by suction, and then the web is dried.
8. A method as claimed in claim 6 or 7 in which after the preliminary bonding the web is passed through a solution of the organic thermosetting resin, through nip rollers and along a drying lattice.
9. A method as claimed in claim 8 in which, during its passage along the drying lattice, the web is heated on its top surface by means of hot air.
10. A method as claimed in claim 6 or 7 in which after the preliminary bonding the web is passed through a solution of the organic thermosetting resin and then up a drying tower.
11. A method as claimed in claim 10 in which, during its passage up the drying tower, the web is heated on both surfaces.
12. A method as claimed in any of claims 6 to 11 in which the solvent for the

organic thermosetting resin is removed and the web is heated under pressure to compress it to a desired density and so as partially to cure the resin.

5 13. A method as claimed in claim 12 in which the web, after partial curing of the resin, is formed into a filter structure and then heated so as to cure the resin fully.

10 14. A method as claimed in any of claims 6 to 11 in which the solvent for the organic thermosetting resin is removed and the web is formed into a filter structure then heated so as to cure the resin.

15 15. A method as claimed in claim 13 or 14 in which the curing of the resin is effected at an elevated temperature which

decomposes any chemical preliminary binder that is present.

16. A method for the preparation of a filter medium substantially as hereinbefore 20 described with reference to and as illustrated in the Example.

17. A filter medium substantially as hereinbefore described with reference to 25 and as illustrated in the Example.

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